XXX. NETWORK SYNTHESIS*

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RESEARCH OBJECTIVES

Our group aims to achieve an improved understanding of lumped electrical networks. During the coming year, we shall be concerned primarily with the following problems.

1. Development of synthesis procedures that lead to transformerless realizations of rational network functions.

2. Extension of known RLCT synthesis procedures to include new types of circuit elements.

3. Determination of properties of transformerless networks.

4. Establishment of performance limitations for networks that contain nonlinear and/or time-variant circuit elements.

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A. NONRECIPROCITY FIGURE OF MERIT FOR PASSIVE RESISTIVE DEVICES

Garg and Carlin[1] recently proposed a nonreciprocity figure of merit M for three-terminal Hall plates.

The purpose of this report is to offer a nonreciprocity figure of merit that applies to passive resistive devices with any number of terminals. The new figure of merit does not reduce to M in the three-terminal case, but has a number of properties in common with it.

The suggested figure of merit M' is the maximum angle at which complex power can be dissipated in the device, divided by $\pi/2$. This figure of merit has the following attributes.

1. M' is a property of the device (rather than being a property of a description of the device).

2. M' lies in the range $0 \leq M' \leq 1$, equalling zero only when the device is reciprocal, and equalling one only when the device can be excited in a purely nonreciprocal manner.

3. M' reflects a fundamental restriction on networks that can be constructed by interconnecting the device, resistors and capacitors (see Appendix).

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4. M' is invariant to embedding in networks of transformers.

The determination of M' is quite straightforward. Indeed, if G denotes a nodal admittance matrix for the device, then

$$M' = \frac{2}{\pi} \tan^{-1} \lambda_{max},$$

where λ_{max} equals the largest root of the equation

$$\left| j(G-G_t) - \lambda(G+G_t) \right| = 0.$$

For a three-terminal device

$$M' = \frac{2}{\pi} \tan^{-1} \frac{\left(\frac{g_{12} - g_{21}}{2}\right)^2}{g_{11}g_{22} - \left(\frac{g_{12} + g_{21}}{2}\right)^2}.$$

Appendix

Restriction 3 is contained in the following theorem.

THEOREM: The natural frequencies of any network constructed from resistors, capacitors, and multiterminal passive resistive devices having a common figure of merit M', are confined to the shaded region of the s-plane shown in Fig. XXX-1.

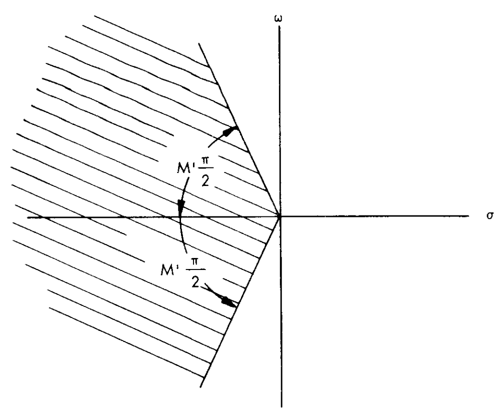

Fig. XXX-1. s-plane.

PROOF: The proof consists of writing down the expression for the complex power absorbed by such a network, interpreting the powers absorbed by the various elements as vectors, and observing that the vectors cannot possibly add to zero (as they must for a natural oscillation), unless s is confined to the shaded region shown in Fig. XXX-1.

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References

1. J. M. Garg and H. J. Carlin, "Network Theory of Semiconductor Hall-Plate Circuits," IEEE Trans., Vol. CT-12, pp. 59-73, March 1965.